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THE COMPARATIVE PERFORMANCE OF FLEXIBLE PACKAGES AND METAL CANS

by

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13. ABSTRACT

This study was conducted to determine the comparative resistance to damage from rough handling abuse of flexible packages and metal cans. Flexible packages made from two laminated materials and standard metal cans of heat-processed food items were evaluated. Two food types, pumpable and semi-solid, were used to determine the effect of product consistency on failure rates. Following vibration and drop tests of case lots of the two types of packages, there was no significant difference in the failure rates of the flexible packages and metal cans. The overall failure rate of the flexible packages was slightly lower than that of the metal cans, and a higher failure rate occurred in both package types when filled with a pumpable product than when filled with a semi-solid product.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Packaging			6			
Flexible food packaging			6			
Food			10, 9			
Laminated plastics			6			
Cans			6			
Metal			0			
Military rations			9			
Tests (laboratory)	8					
Field tests	8					
Rations	9		9			
Flexible packages	9					
Containers	9					
Durability	4		7			
Comparison	4					
Resistance			7			
Damage			7			
Pumpable			0			
Semi-solid			0			

FOREWORD

The work covered by this report was performed under Project 1J662713D552, Packaging Technology, Task 02 - Design of Flexible Packaging Systems.

This effort was undertaken as part of a project to develop improved packaging for components of operational rations. Because of the logistical advantages of flexible packages over rigid metal cans for military applications, extensive effort has been devoted to the development of a flexible packaging system for heat-processed foods. The data presented in this report show the comparative rough handling durability of flexible packages and comparable size metal cans used for heat processed foods.

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1. Introduction

Extensive research and development effort has been expended to develop a flexible package for heat-processed foods.[1] Since this packaging system is intended to replace metal cans in operational rations, it is essential that comparative performance, relative to handling durability between the metal can and the flexible package be established. Laboratory testing of flexible packages have been conducted with favorable results;[2] however, to provide a direct comparison of the durability of the two methods of food packaging, the study discussed in this report was conducted.

The primary objective of this study was to compare the resistance to damage from rough handling of flexible packages and metal cans. In addition to a direct comparison of cans and flexible packages, the test was designed to provide additional comparisons as follows:

- Comparative performance of two flexible packaging materials.
- Comparison of damage from two product types: pumpable (chicken-ala-king for flexible packages and chicken & noodles for cans), and placeable (beefsteak).

The rough handling tests to which the cans and flexible packages were subjected in this study were not intended to represent any specific transportation and handling system. The vibration and drop

tests are commonly used to simulate transportation experience but, in this test, were purposely carried to a magnitude to cause extraordinary and severe stress. Since the tests used were extremely severe, the results should not be interpreted as indicative of lack of durability of metal cans.

2. Materials

a. Flexible Packages

Two commercially available heat-processable materials were used for this study. They are as follows:

(1) 0.076-mm (0.003-inch) blend of high density polyethylene and polyisobutylene 0.0089-mm (0.00035-inch) 1145-0 Aluminum Foil Alloy 0.0127-mm (0.0005-inch) polyethylene terephthalate.

(2) 0.076-mm (0.003-inch) high density polyethylene 0.0089-mm (0.00035-inch) 1145-0 Aluminum Foil Alloy 0.0127-mm (0.0005-inch) polyethylene terephthalate.

Pouches were fabricated from the two materials using previously established optimum sealing conditions for each material. The pouches were 114.3 mm (4.5 inches) x 177.8 mm (7 inches), with 9.5-mm (3/8-inch) wide side and bottom heat seals.

b. Metal Cans

All cans were 300 x 200 sanitary cans conforming to the requirements of Federal Specification PPP-C-29.

c. Paperboard Folders

A protective package to provide improved physical endurance is considered an integral part of the flexible package. All flexible packages tested were, therefore, adhered to a paperboard folder as shown in Figure 1. The folders were fabricated from 17-point bending grade paperboard.

d. Shipping Containers

Shipping containers for both cans and flexible packages were fabricated from 200-pound test domestic corrugated fiberboard. The containers were style RSC, with stitched manufacturer's joints and glued top and bottom flaps. Shipping container dimensions to accommodate 72 flexible packages or cans were as follows:

(1) Flexible packages. 381 mm (15 inches) x 247.7 mm (9 3/4 inches) x 279.4 mm (11 inches).

(2) Metal Cans. 450.9 mm (17 3/4 inches) x 301.6 mm (11 7/8 inches) x 152.4 mm (6 inches).

3. Test Products

To provide an indication of the effect of type of product on the susceptability to damage during rough handling, products representing the two extremes, liquid and semi-solid, were chosen. For both cans and flexible packages, the semi-solid product used was beefsteak. The more fluid (pumpable) product used for the cans was chicken and

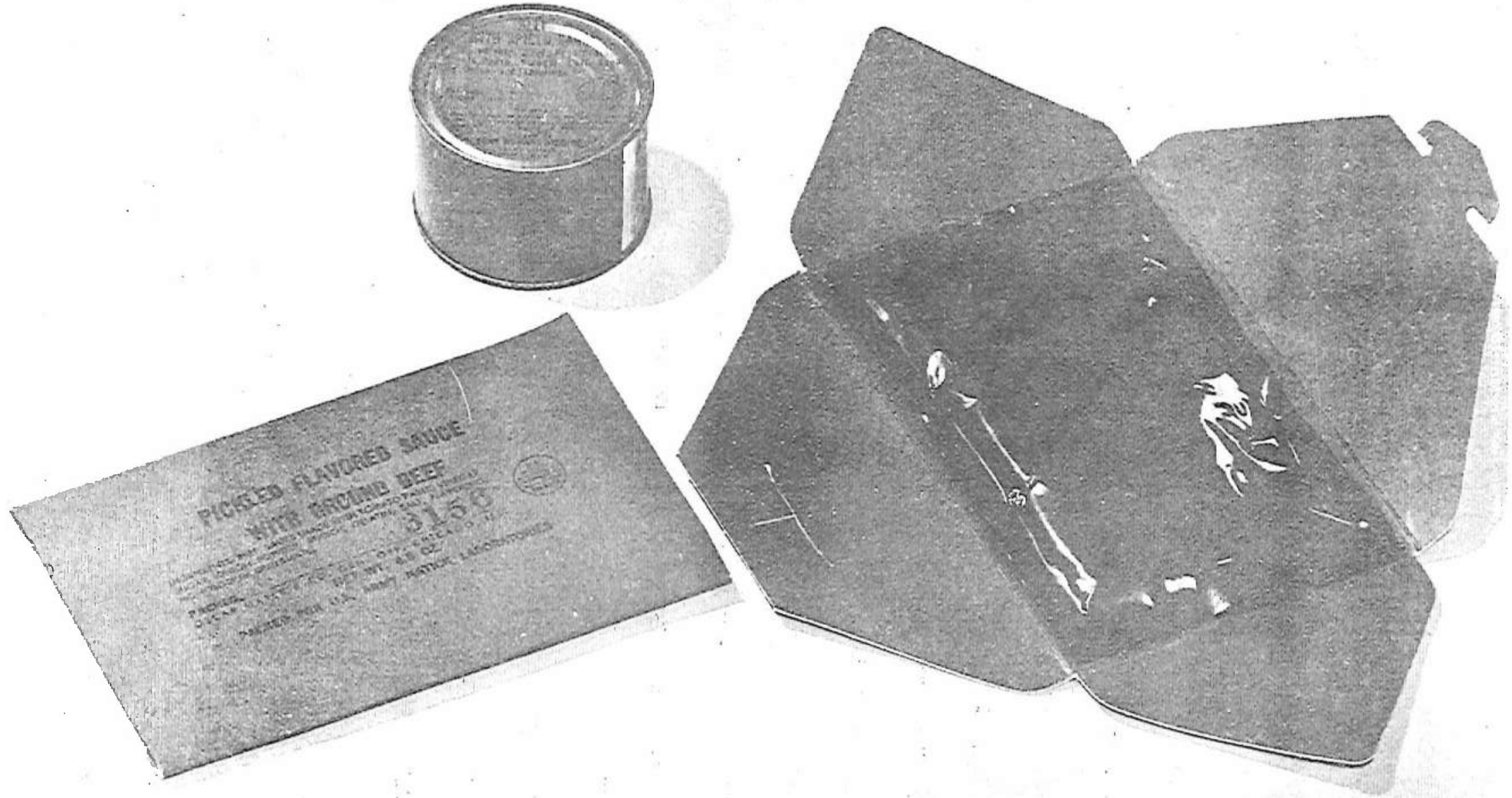

Figure 1. Ration Component in Can and Flex Pack.

noodles; and chicken-ala-king, having a solids-to-liquid ratio approximately the same as chicken and noodles, was used for the flexible packages.

4. Equipment

a. Rough Handling Tests

(1) Vibration. Vibration treatment was performed with an L.A.B. combination vibration tester operating at 268 cycles per minute, producing an acceleration of one G (Figure 2).

(2) Drop Test. Drop tests were conducted using a Gaynes spring-loaded, leaf-type drop tester (Figure 3).

b. Biotesters

(1) Cans. The test apparatus (Figure 4) was designed for this study. The apparatus consists of a vessel in which cans are immersed in bacterial contaminated water. Timer controlled solenoid valves produce vacuum level fluctuations in the vessel within preset ranges. The range between 43.88×10^3 Pascal (Pa) Absolute (17 in. of Hg) and 27.01×10^3 Pascal (Pa) Absolute (22 in. of Hg). The vacuum level fluctuations cause flexing of the can ends and pressure fluctuations within the headspace of the cans. The pressure changes in the headspace and flexing of the can ends cause bacteria-laden water to be drawn into the can if a defect is present.

(2) Flexible Packages. The biotester for pouches (Figure 5) is a device which mechanically creates a pressure differential in

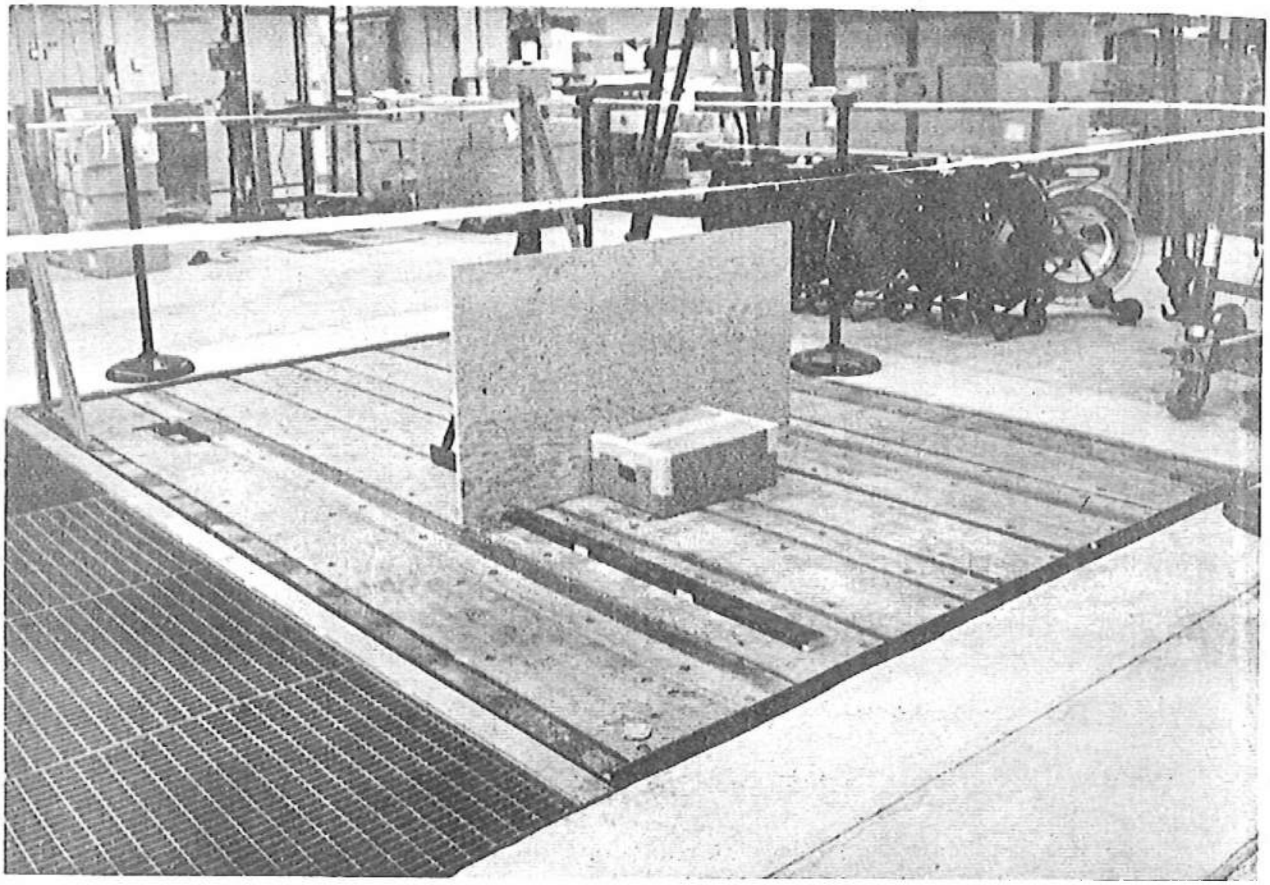

Figure 2. Vibration Tester.

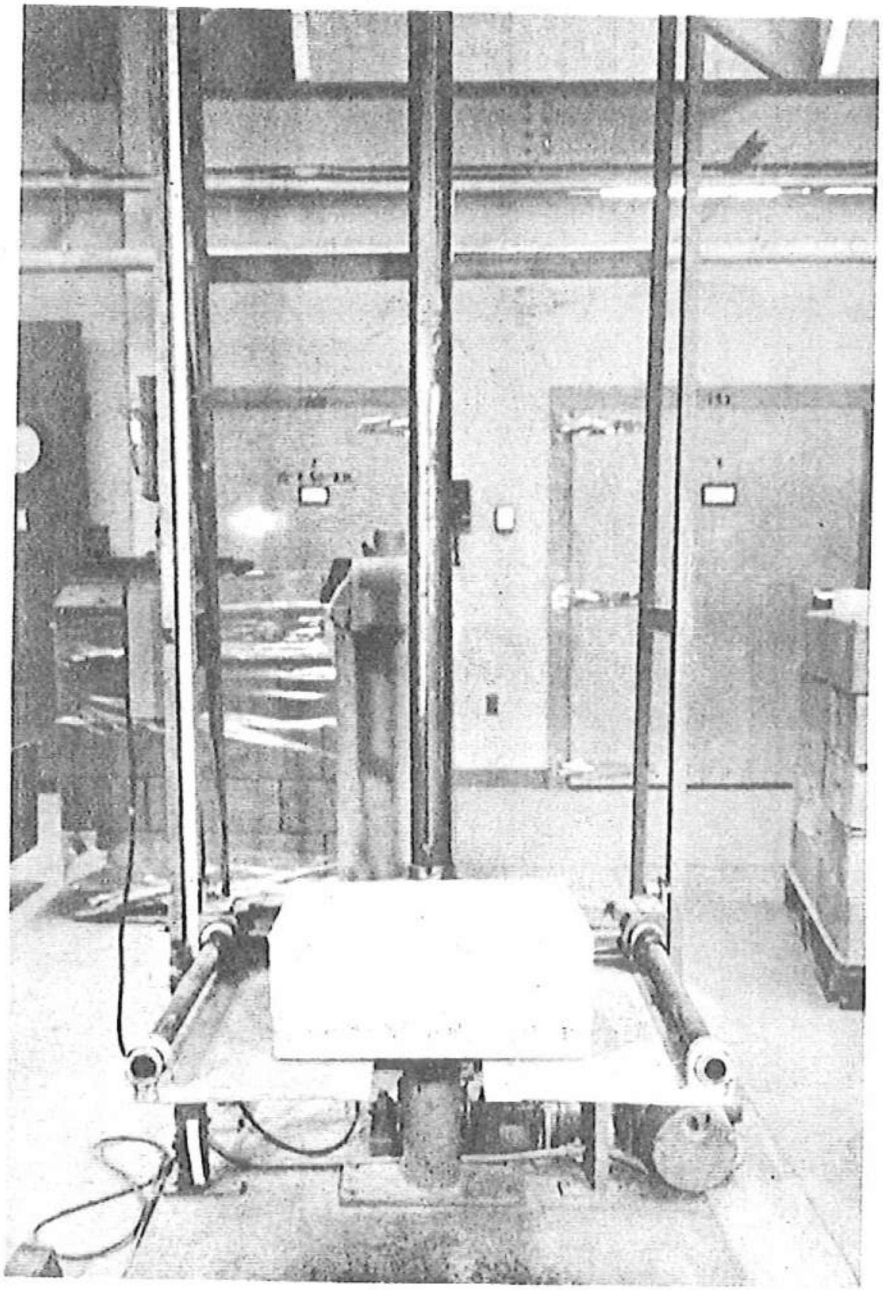

Figure 3. Drop Tester.

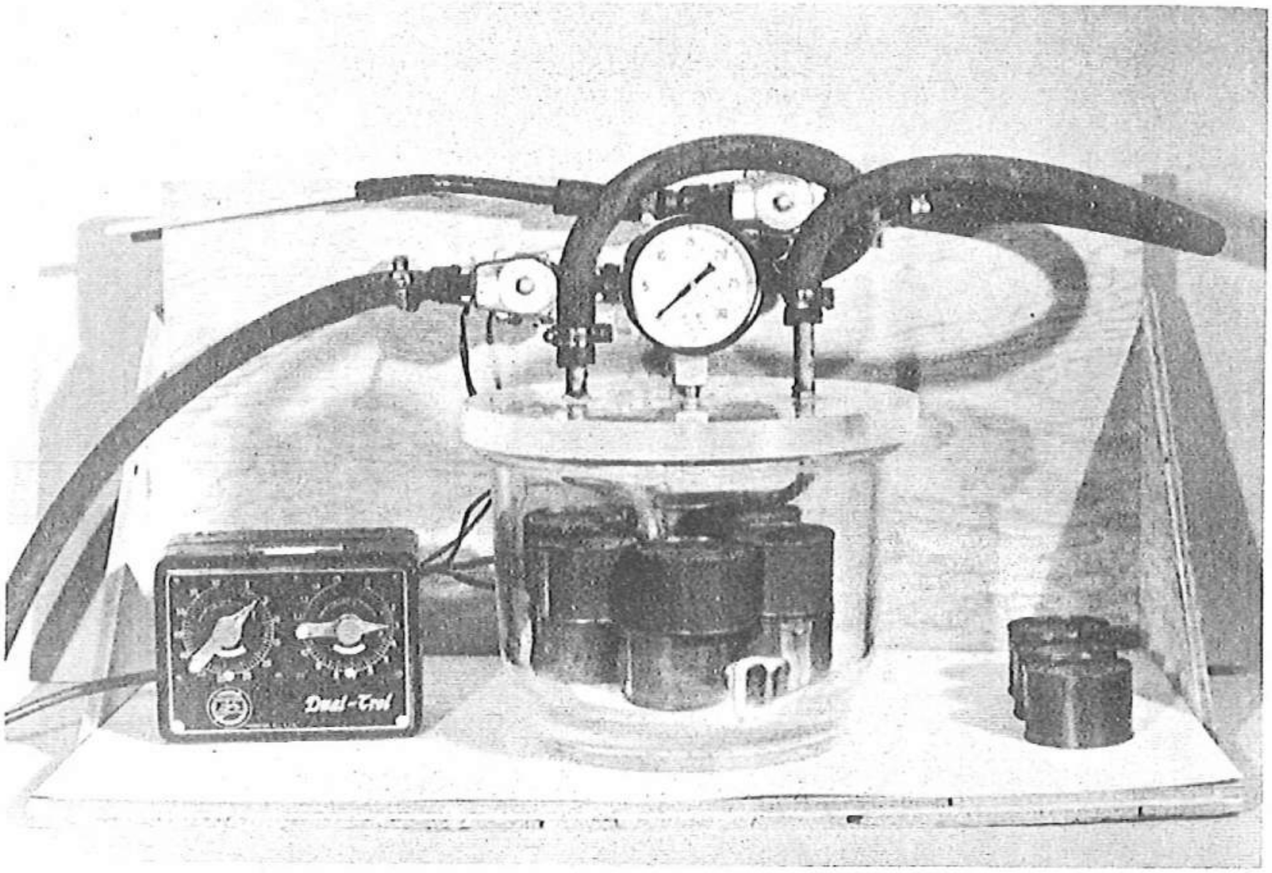

Figure 4. Can Biotester.

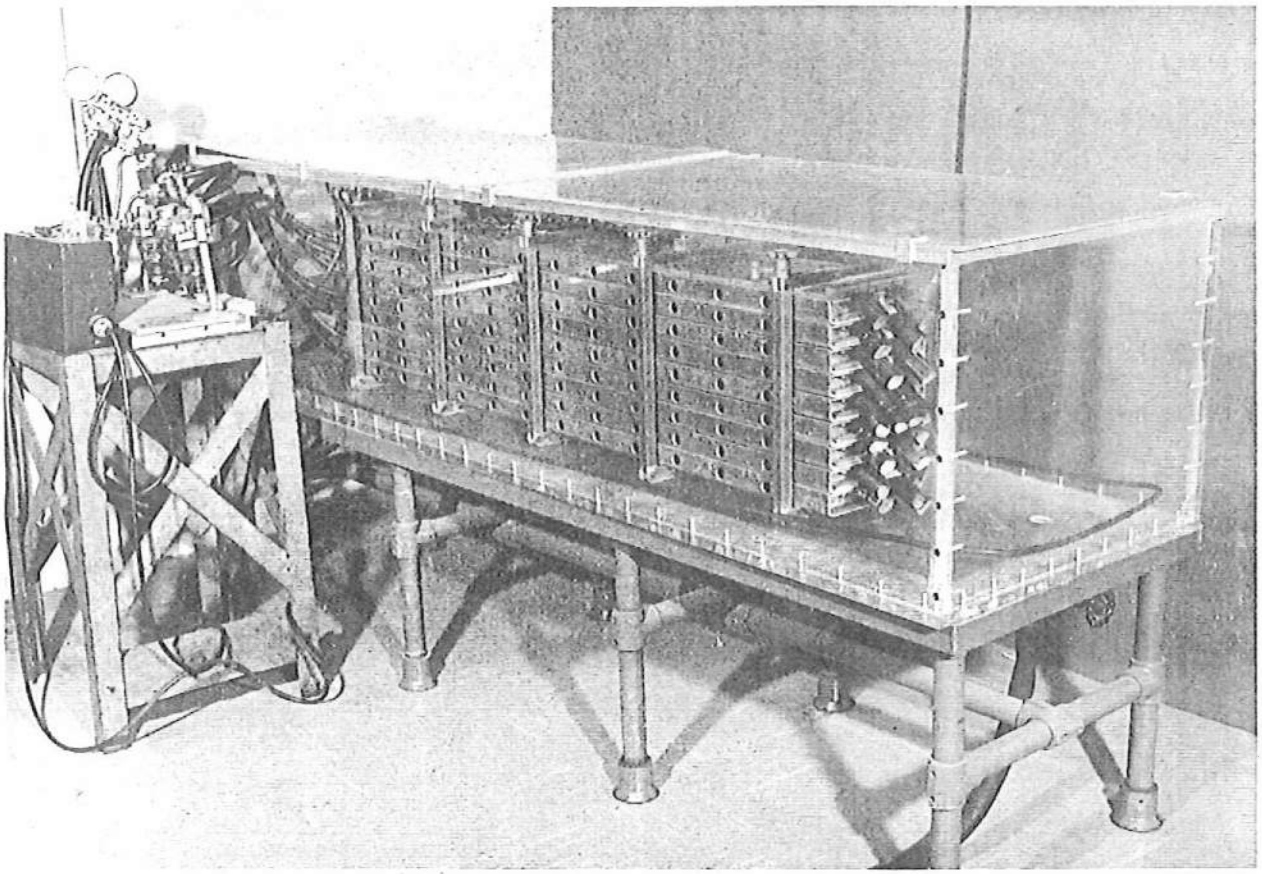

Figure 5. Flexible Package Biotester.

pouches while they are immersed in a water-bacteria solution.[3] Two metal channels 44.5 mm (1 3/4 inches) wide and spaced 22.2 mm (7/8 inch) apart are pressed and released in altering sequence to produce a kneading action within the pouch, pumping water-bacteria into the pouch if a defect is present. Uniform pressure is provided by pneumatic tubes located in the metal channels.

c. Auxiliary Equipment

Standard laboratory bag fabrication, vacuum sealing and processing equipment were used in the preparation of test packages.

5. Experimental

a. Preparation of Test Samples

(1) Flexible Packages. The flexible packages (Figure 6) were filled with approximately 154 g. (5.5 ounces) of test product. The chicken-ala-king was a commercial, frozen product and was hand-filled into the flexible packages while frozen. The beefsteaks were individual pre-cooked steaks, approximately 101.6 mm (4 inches) x 63.5 mm (2 1/2 inches) x 12.7 mm (1/2 inch). Each steak was packaged with a nominal amount of natural juices from the previous cook. All flexible packages were vacuum-sealed at a vacuum level of $6.75 \times 10^3 \pm 1.69 \times 10^3$ Pascal (Pa) Absolute ($28 \pm 1/2$ inches of mercury) to assure a headspace gas volume of 6 cc or less.

Following vacuum-sealing, all flexible packages were inspected

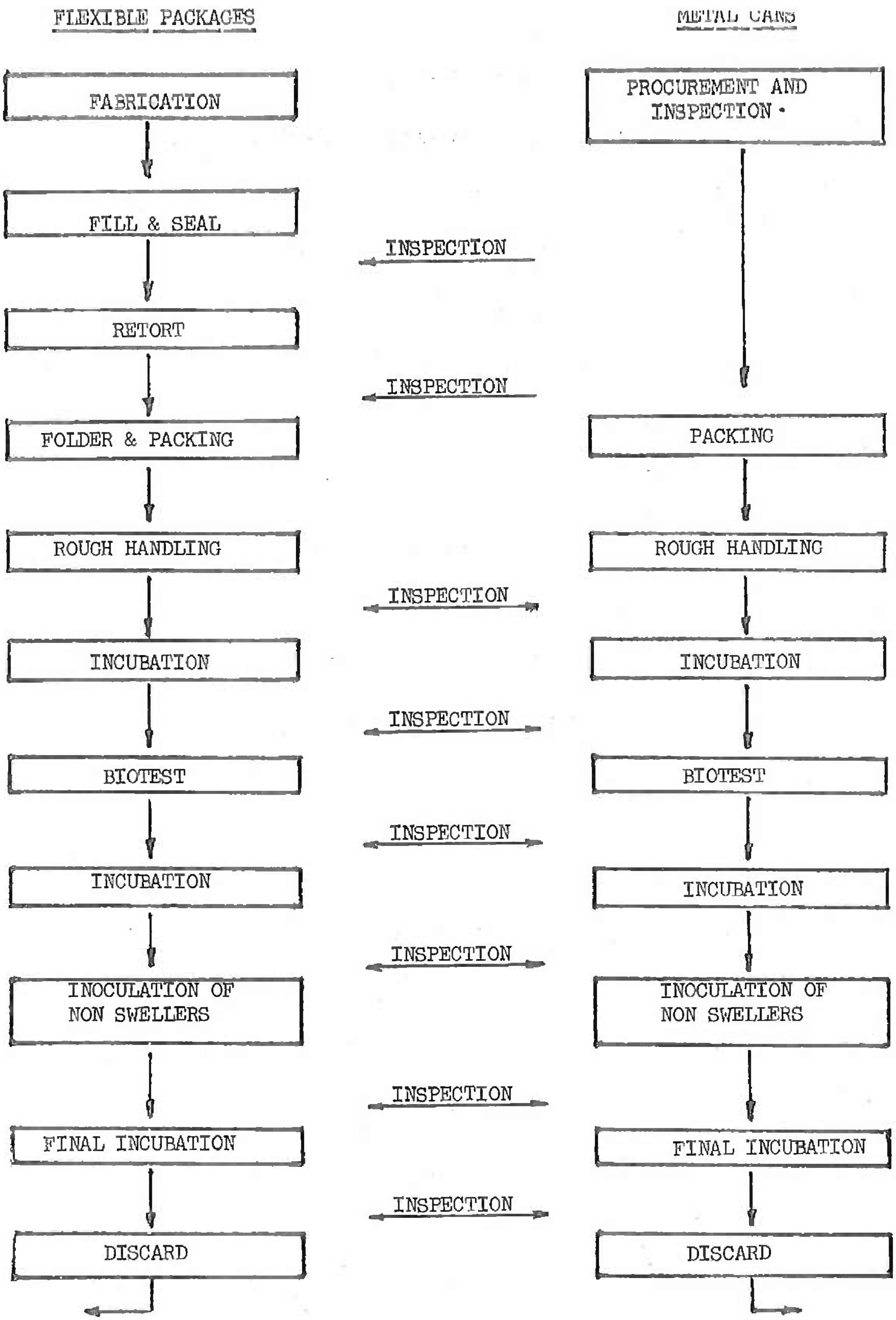

Figure 6. Summary of Experimental Test Procedures.

visually for seal defects or visible damage and placed into retort racks for processing. The retort racks (Figure 7) contained 19.1-mm (3/4-inch) slots with 12.7-mm (1/2-inch) spacing between individual packages. The heat process used was a steam-air cook for 40 minutes at 115°C (240°F). Overriding air pressure during the cook and cooling cycles was 239.22 x 10^3 Pascal (Pa) Absolute (20 psig), with the overriding air pressure being maintained until the packages cooled to approximately 71°C (160°F).

The retorted packages were then glued into paperboard folders and packed into fiberboard shipping containers. The shipping containers were provided with die-cut partitions and center pads, resulting in eight cells, each containing nine foldered packages.*

(2) Cans. The cans (Figure 6) of product were procured through the Defense Personnel Support Center and were in accordance with Military Specifications MIL-C-11076 - Chicken and Noodles, Canned and MIL-B-1072 - Beefsteak, Canned. Each can was inspected prior to packing and all cans showing visible evidence of damage were discarded. They were then repacked 72 per shipping container in 3 tiers of 24 cans each (6 cans by 4 cans).

b. Rough Handling

The shipping containers for flexible packages and cans were

*It was determined from preliminary studies that there was no significant difference in the performance of flexible packages packed flat or on edge.

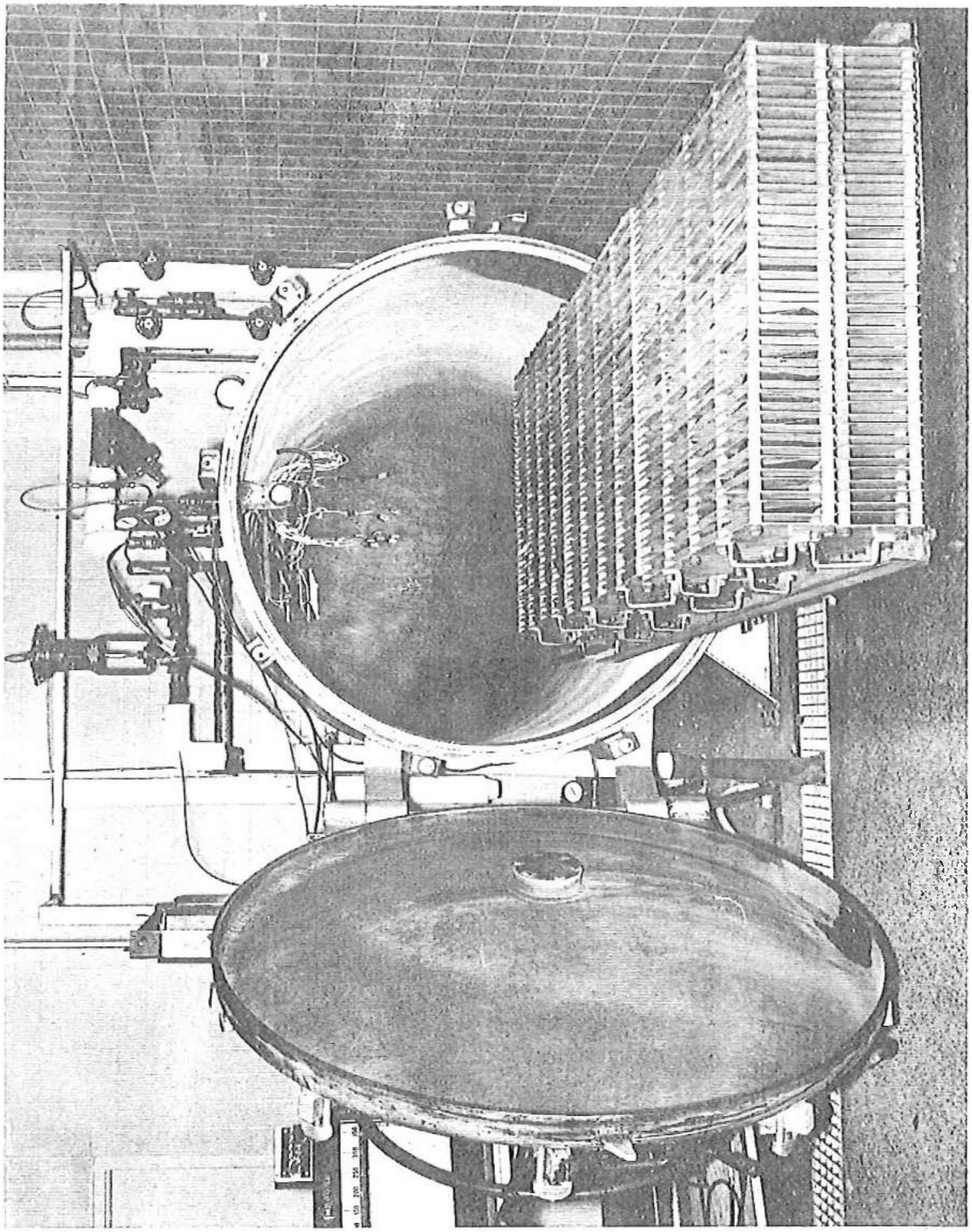

Figure 7. Steam-Air Horizontal Retort.

subjected to identical rough handling tests as follows:

(1) Vibration. One hour of vibration in accordance with ASTM D-999-63 (268 cycles per minute).

(2) Drop Test - Following the vibration stage, the containers were subjected to 10 drops from a height of 18 inches in accordance with ASTM D-775-68, Objective B, in the following prescribed sequence:

Drop No. 1 A corner drop on the 5-1-2 corner.

Drop No. 2 An edge drop on the shortest radiating edge from that corner.

Drop No. 3 An edge drop on the next shortest radiating edge from that corner.

Drop No. 4 An edge drop on the longest radiating edge from that corner.

Drop No. 5 A flat drop on one of the smallest faces.

Drop No. 6 A flat drop on the opposite smallest face.

Drop No. 7 A flat drop on the next larger face.

Drop No. 8 A flat drop on the opposite next larger face.

Drop No. 9 A flat drop on the largest face.

Drop No. 10 A flat drop on the opposite largest face.

Figure 8 shows the identification system of the faces, edges, and corners of the containers. At this point, all containers were opened and the flexible packages were removed from their folders and inspected for damage.

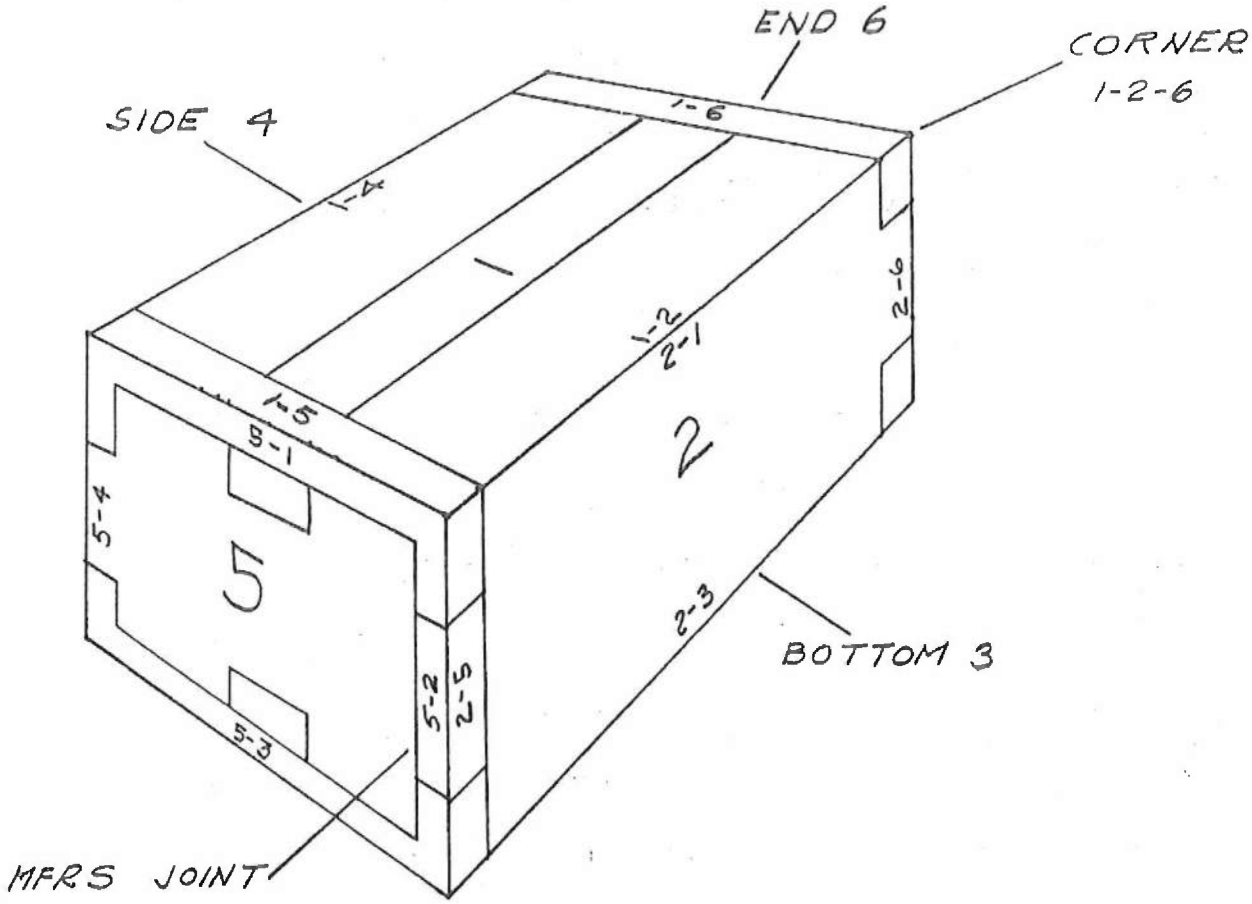

Figure 8. Identification of the faces, edges, and corners of shipping container.

c. Biotesting and Incubation

(1) Incubation prior to biotesting. A portion of the flexible packages were stored for 28 to 35 days at Standard Conditions (22°C or 72°F, 50%RH). The purpose of this incubation was to assure that a commercially sterile product was attained with the process used and to determine if recontamination of any defective packages occurred during handling and subsequent storage as a result of airborne organisms.

(2) Biotest

a. Procedure. The biotest cycle for both cans and flexible packages was 90 cycles, i.e. the flexible package had both ends kneaded 90 times and the can had both ends flexed 90 times.

b. Bacteria Concentration. The solution used for both cans and flexible packages in the biotest stage was a water solution with a 24-hour culture of Aerobacter Aerogenes, a gas-producing micro-organism. The cell concentration was 1×10^6 cells per ml of tank water. To assure adequate concentration and culture viability at the start and finish of each day, a can or pouch was injected with 1.5 ml of the solution from the inoculated baths.

(3) Incubation following biotesting. After biotesting, the pouches and cans were incubated at 35°C (95°F) for 10 days. During that time those pouches or cans that were defective and allowed microbial penetration during biotesting became swollen (Figure 9).

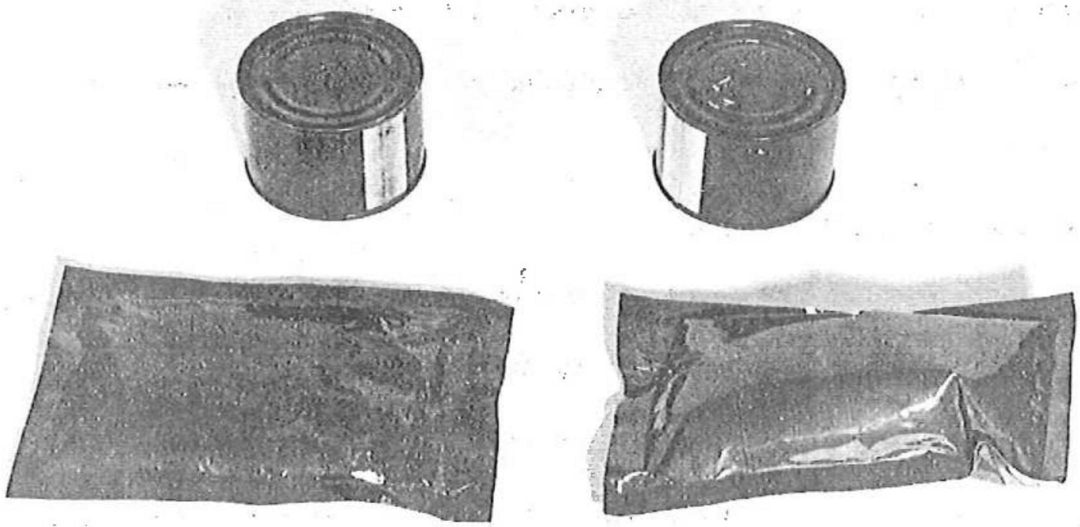

Figure 9. Swollen Flexible Package and Can with Controls.

Upon completion of the incubation stage all of the pouches and cans that did not swell were inoculated with 1.5 ml of a solution identical to that used in the biotester. The purpose of this inoculation was to assure that the contents of these packages would support growth of the test organism and that the package did not have a defect of sufficient magnitude to allow gases generated to escape.

6. Results and Discussion

Table I shows the total numbers of containers tested and number of packages which were damaged during testing. The packages included as failures in these tables are those which showed visible leakage after completion of the test cycle and those which showed swelling after biotesting and incubation. After identical rough handling tests, there was no significant difference in the performance of material No. 1 and the metal cans. Material No. 2, however, was significantly* better than either the metal can or material No. 1, when filled with a pumpable product. No significant difference was found between the two flexible materials or between either of the flexible materials and the metal can when filled with a semi-solid product.

In addition to the packages which failed under the failure criteria described above, twenty cans (18 chicken and noodles and 2

*At 90% Confidence Level

TABLE I

Test Results

	Pumpable Product (Chicken-Ala-King)			Semi-Solid Product (Beefsteak)		
	Number Tested	Number Failed	Percent Failure	Number Tested	Number Failed	Percent Failure
Metal Cans[a]	1440	32	2.22	720	4	0.56
Flexible Material[b] # 1	1440	30	2.08	720	2	0.28
Flexible Material[c] # 2	720	5	0.7	720	4	0.56

[a]Pumpable product in the cans was chicken and noodles.

[b]Flexible Material #1 = 0.076-mm (0.003-inch) blend of high density polyethylene and polyisobutylene/0.0089-mm (0.00035-inch) 1145-0 Aluminum Foil Allow/0.0127-mm (0.0005-inch) polyethylene terephthalate.

[c]Flexible Material #2 = 0.076-mm (0.003-inch) high density polyethylene/0.0089-mm (0.00035-inch) 1145-0 Aluminum Foil Alloy/ 0.0127-mm (0.0005-inch) polyethylene terephthalate.

beefsteak) sustained sufficient damage to be classified as major defects in accordance with accepted can inspection procedures.[4] No visible damage of this type was evident in any of the flexible packages.

It was also observed during the tests that the fiberboard containers suffered considerably more damage from cans than from the flexible packages (Figure 10). In all tests, after the second or third drop, it was necessary to reinforce the boxes containing metal cans before the test could be completed. Reinforcement was necessary because of extensive scoreline breaks, whereas no breaks occurred in the shipping containers which contained flexible packages.

Flexible packages and cans which did not show swelling after biotesting and incubation were inoculated as described previously. In all instances, positive results, swelling, were obtained within 3 days of incubation after final inoculation. This assured that conditions inside each package would support growth of the organism and that no defective packages were undetected because of loss of gases generated.

7. Conclusions

The primary purpose of this study was to obtain a direct comparison of the durability of metal cans and flexible packages of similar size, containing similar products. The data shows that the two flexible materials included in the study were capable of

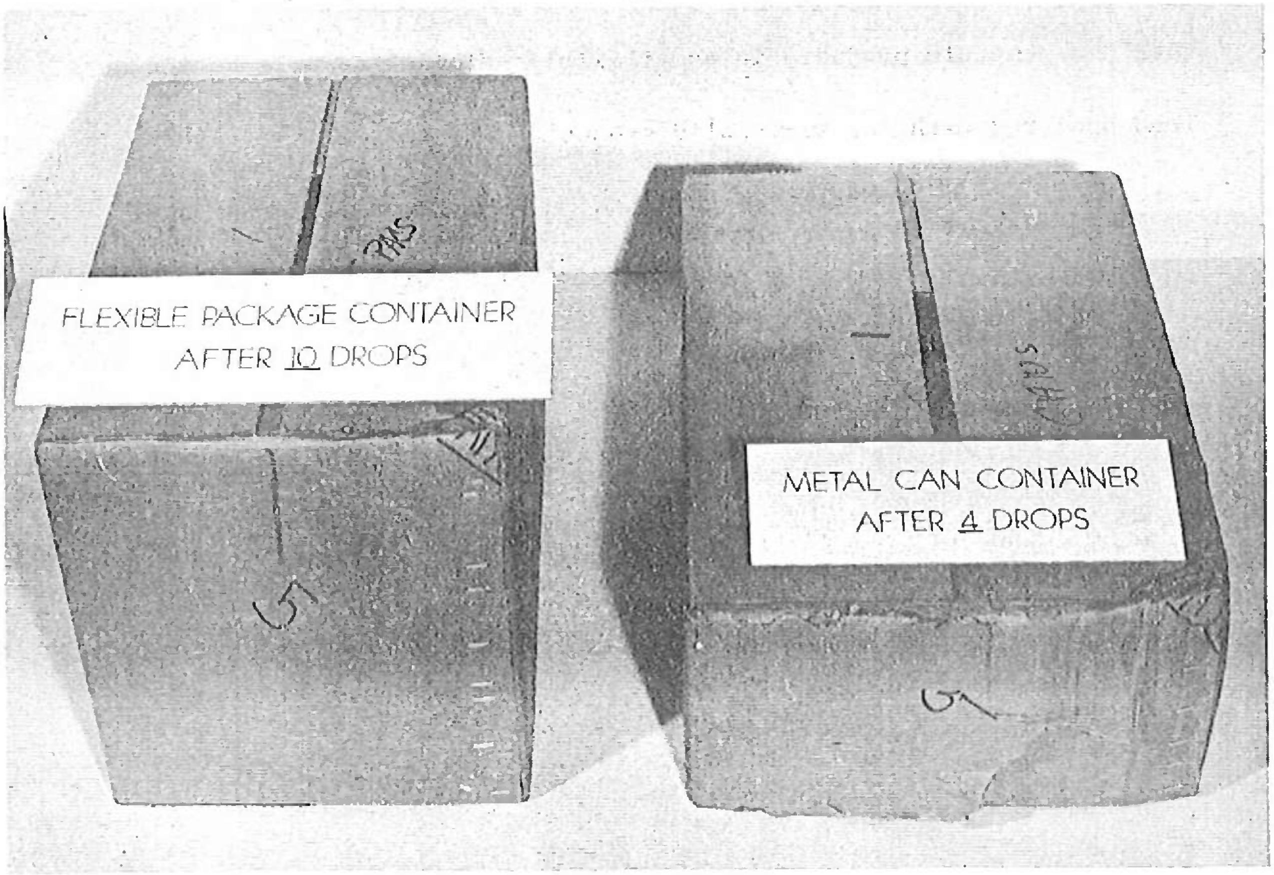

Figure 10. Damaged Containers after Rough Handling.

withstanding drop and vibration hazards at least as well as the metal cans.

The data from this study also showed that more damage occurred with the pumpable product, in one flexible material as well as the cans, than occurred with the semi-solid product. Although both flexible materials showed excellent performance, a difference in performance was found between the two materials when filled with the liquid product.

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